Ministry of
Transportation and
Communications

MI-78

STUDY [illegible]-22

[illegible]NCH
[illegible]ER NORTHERN [illegible]LES
INCLUDING [illegible] P[illegible]
LANES SU[illegible]BU[illegible]

MATERIALS [illegible]O[illegible]TION

ENGINEERING MA[illegible]S [illegible]FICE

CASE STUDY OF

CONTRACT 83-222

HWY. 69 - FROM THE FRENCH RIVER

NORTHERLY 19.6 MILES INCLUDING

FOUR PASSING LANES

SUDBURY DISTRICT

BY

P. KORGEMAGI

SR. BITUMINOUS ENGINEER

APRIL, 1985

Summary

Highway 69, from the French River northerly for 19.6 miles was resurfaced under Contract 83-222 with recycled hot mix. During construction the recycled pavement showed evidence of flushing in the wheel tracks. On July 11, 1984 following a request from the Region for a site visit, Bituminous Section personnel recommended, in agreement with the Regional Quality Assurance Section to change the asphalt cement grade from Gulf RA-75 to 300/400. RA-75 is a soft grade of asphalt cement used to obtain higher Abson recovered penetration values in recycled hot mix. In spite of the change in asphalt cement grade, the pavement continued to show some flushing.

In the fall, following three accidents on that portion of the pavement where RA-75 was used, four sections were repaved. These sections were on curves and required 2652 tonne of hot mix. Presently there is one lawsuit over one of the accidents. Treatment of the rest of the pavement in this Contract will depend on evaluation in the spring of 1985.

Analysis of data from testing carried out during the Contract as well as subsequent investigations indicate that the virgin fine aggregate used in the mix design of the recycled hot mix was substantially coarser than specified in the contract. This resulted in very low percent voids and percent VMA. Incorrect interpretation of laboratory test results prevented remedial action during the course of the Contract.

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Pavement Rehabilitation Design

The rehabilitation method selected was to recycle hot mix at a ratio of 70/30. The pavement rehabilitation design consisted of recycled hot mix resurfacing over the existing pavement, padding over about 50% of the job, patching beyond the limits of the Contract and a few areas of binder and surface. The surface course thickness was 40 mm on padded areas or on new binder, and 50 mm for resurfacing. Any granular lifts received 2-40 mm lifts of binder course followed by 50 mm of surface course.

Reclaimed Asphalt Pavement

The reclaimed asphalt pavement was processed from an existing stockpile located at a site in Burwash Township, 24 km south of Estaire. The test results on the RAP are shown as control charts in Figure 1 and summarized in Table 1. The RAP was tested twice a day during production from June 5 to Aug. 3, 1984. A total of 55 tests were taken.

The RAP had less than an average variation as measured by the coefficient of variation on the 4.75 mm sieve. The coefficient of variation is defined as the standard deviation divided by the mean and is thus a relative measure of variation. It can be helpful in comparing several sets of similar data that differ in mean value but have some commonality in relative variation. The average coefficient of variation for both Northern and Southwestern Regions is 8.6% and for Contract 83-222 is 8.0%.

The asphalt cement content and gradation of the sample of RAP used for the mix design when compared to the average value of the 55 tests shows that the gradation of the RAP as tested was marginally finer than that of the mix design sample.

	A.C.	13.2 mm	4.75 mm	600 um	300 um	75 um
MIX DESIGN SAMPLE	4.3	7.2	36.3	76.9	86.9	95.8
AVERAGE OF 55 TESTS	4.1	6.9	35.0	75.5	86.1	95.7
DIFFERENCE	0.2	0.3	1.3	1.4	0.9	0.1

Hot Mix Aggregates

The hot mix aggregates were produced from Feb. 21 to April 12, 1984 from the Pagnutti Pit. A summary of the test data is listed in Table 2.

The gradation of the virgin fine aggregate used for the mix design when compared with the average of the tests shows that the gradation as tested was finer than the sample used for mix design.

	9.5	4.75	2.36	1.18	600	300	150	75
MIX DESIGN SAMPLE	0.9	18.2	37.1	57.9	77.5	90.6	95.7	97.6
AVERAGE OF TESTS	0.4	13.5	34.5	55.6	74.8	88.4	94.3	96.4
DIFFERENCE	0.5	4.7	2.6	2.3	2.7	2.2	1.4	1.2

The combination of the RAP and the virgin fine aggregate deviations and the increase in the 75 um sieve resulted in the mix on the road having a finer gradation and therefore lower voids and VMA than the original mix design. This change when combined with the low voids and VMA outside the Marshall requirements of the mix design conspired to produce a pavement which was susceptible to flushing under traffic.

Mix Design

The materials and composition of the mixture are set out in Special Provision 327 - Recycled Hot Mix. The regional mix design sheets are attached as Figures 2 to 5. The S.P. (Figure 6) required the fine aggregate to grade fine and clean. The fine aggregate used in the mix design graded coarse and with a fines content of 2.4% as shown in Figure 3. The generally acceptable definition of fine and clean was a sand with almost all of it passing the 600 um sieve, less than 5% passing the 75 um sieve and the majority of the sand betwen the 100 and 300 um sieve. The definition of fine and clean for fine aggregate as defined by the S.P. according to Northern Region, is open to some interpretation. This S.P. now has a specific gradation for virgin fine aggregate.

The fine aggregate used produced a mix which didn't meet two Marshall requirements, % voids and % VMA. The accepted mix had 2% voids where 3% is the minimum and 14.4% VMA where the required minimum was 15.3%. One reasone this mix was accepted was because of the two opposing philosophies prevelent in the Ministry at the beginning of the recycling program. One was "to make recycling work and solve the problems later". The other philosophy was that all recycled mixes must meet the Marshall requirements. At a recycling ratio of 70/30 it was common to miss at least one Marshall requirement, so it was often convenient to follow the most expedient Head Office guideline.

Hot Mix Production

The hot mix production was started with an incorrect virgin fine aggregate which gave a marginal mix design. Subsequently, the gradation of the virgin fine aggregate changed and the gradation of the RAP changed to make the mix worst. With a finer gradation for both the virgin fine aggregate and the RAP then indicated by the mix design samples the mix as produced had less voids than designated. When testing indicates very low voids, the actual voids in the mix are less than indicated by the testing. Figure 14 illustrates this point.

The mix design set the percent retained on the 4.75 mm sieve at 42.2%. This was based on the following proportions; 70% RAP, 15% coarse aggregate and 15% fine aggregate. On June 12 after six tests showed low stone content the proportions were changed to 70% RAP, 20% coarse aggregate and 10% fine aggregate. However, the target for stone content remained at 42.2% where in fact the recalculated stone requirement was 46.1%. This difference becomes important in applying the requirements of Directive B-138. The stone content in the RHM as measured by the acceptance tests was 41.1% stone. The 5% difference in stone indicates a problem in the contractor's process and the Ministry's ability to detect it.

Acceptance Test Results - Field Laboratory

The field laboratory tests the hot mix for acceptance. All hot mix aggregates and the RAP were also tested by the same laboratory. Seventy-six tests on the recycled hot mix were done from June 7 to Aug. 8, 1984. Test results are shown as control charts in Figure 7 and summarized in Table 3.

Mobile Laboratory Test Results

The mobile laboratory is used as an independent check on asphalt cement content and gradation and to determine Marshall values and percent compaction during the term of the contract. The results are also used as a permanent record of the characteristics of the mixture. Sixty-two plant checks were done by the mobile laboratory on this contract as well as eleven checks for percent compaction. Results are listed in Table 4. Figure 8 is the control chart for % voids and % VMA. Fifty-eight cores were taken and tested in compliance with Directive B-138, see Table 7.

Regional Laboratory Test Results

The regional laboratory tests plant check samples from the field. These samples are taken adjacent to alternate acceptance samples. These results are used as an independent check on asphalt cement content and gradation and to determine the Marshall values during the term of the contract and for permanent record.

Directive B-42 "Minimum Frequencies of Production Sampling and Testing" states, with reference to the mobile and regional laboratories testing on one contract, the following "Discretion to be used on frequency of sampling/testing mix (to minimize duplication) when Regional Mobile Lab. is testing simultaneously". It is recommended that when the mobile laboratory is testing on any contract that samples not be sent to the regional laboratory to prevent duplication of work.

Test results are summarized in Table 5 and Figure 9 is the control chart for the % voids and % VMA.

Correlation

The purpose of any correlation program is to provide participating laboratories with a means of evaluating their relative performance in testing with a view to improve precision and eliminate bias. Laboratories aware of large departures from the mean test result should review their procedures and equipment, make appropriate changes and improve their performance.

The mobile laboratory doing the testing on this contract had a correlation result on percent voids 0.0% in 1983 and 0.5% high in 1984. However, during the contract a correction factor of +0.9% for percent voids was used. A test result of 1.0% voids was assumed to be 1.9% voids. This correction factor was calculated a number of years ago and was based on the average difference between the mobile and regional laboratory over one construction season.

The use of this correction factor resulted in lack of appropriate action being taken to adjust the mix during the course of the contract.

At the time of the site visit by Bituminous Section personnel, the immediate reaction was to replace the soft asphalt cement with 300/400 grade to eliminate the flushing (see Figure 11). It was assumed that the percent voids from the mobile laboratory with the 0.9% correction was representative of the hot mix and therefore met the mix design.

Asphalt Cement

The asphalt cement on this project was originally selected as 300/400 grade. In order to obtain higher results in the recovered penetration tests, RA-75 supplied by Gulf Canada was substituted, see Figure 10. The RA-75 has a penetration value of 500 plus. No specifications for RA-75 were obtained by the Ministry prior to its use. RA-75 was used in Contract 81-200 in about a mile of Hwy. 17 with no apparent problems with performance. During the 1984 construction season

RA-75 was used in two contracts in Southwestern Region, Contracts 84-05 and 84-06 also with no apparent problems with performance.

In the fall of 1984 on Hwy. 69 after three accidents on pavement in which RA-75 was used four curves were repaved. This involved 2652 tonnes of hot mix. Treatment of the rest of the pavement in the Contract will depend on evaluation in the spring of 1985.

Asphalt cement test results are summarized in Table 6. The 300/400 grade asphalt cement had a normal variation in penetration and viscosity. The RA-75 had a mean penetration value of 525.8 and a high variation. The Abson recovery penetration result varied from 81 when tested in Northern Region to a high of 176 when tested in Downsview.

The flushing on Hwy. 69 was worse in the pavement with the RA-75 than in the pavement with 300/400. Flushing is the upward movement of asphalt in pavements resulting in a formation of a film of asphalt in the surface. The flushing on Hwy. 69 consisted of a film of asphalt cement and aggregate fines on the surface of the pavement in the wheel tracks.

The cause of the flushing was basically due to not meeting the Marshall requirements in the mix design and this was due to the use of the coarse virgin fine aggregate. The actual mix had less voids than the design mix because of the deviations in the virgin fine aggregate and the RAP. The addition of the correction factor of +0.9 to the percent voids resulted in not identifying the real problem with the mix design. The mix design was continuously and conscientiously adjusted to resolve the problem, as is seen by the control charts. However, the real problem was not identified and could only be addressed through the use of an appropriately graded virgin fine aggregate.

Figures 12 and 13 are results from cores cut and tested by Northern Region. Figure 12 shows results of cores taken in the RA-75 pavement and Figure 13 shows results of cores taken in the 300/400 pavement. The obvious differences are in percent compaction and percent voids in the pavement (% VIP); with RA-75 at 99.6% and 1.5% average and the 300/400 at 97.5% and 3.7% average. These results are due basically to the fact that RA-75 is a softer grade of asphalt cement and therefore more workable. The RA-75 is doing what it was designed to do.

Conclusions

1. The virgin fine aggregate chosen was not as described by the contract documents.

2. The mix design selected did not meet Marshall requirements on two parameters.

3. The virgin fine aggregate and the RAP gradation were finer when tested for production as compared to the mix design samples. This change was to the detriment of the mix.

4. The pavement flushed due to the selection of the incorrect virgin fine aggregate and a marginal mix design. The flushing was worse where the softer grade of asphalt cement (RA-75) was used.

5. A correction factor of +0.9% for voids was used. This inhibited corrective action being taken during the course of the contract.

Recommendations

1) Recycled hot mix for surface courses should meet the Marshall requirements.

2) No correction factors should be used for test results. If a correlation program identifies a large deviation in a test result by one laboratory then that laboratory must identify what is causing the deviation and correct it.

3) The correlation results of the mobile laboratory were acceptable for the last two years. The present criteria to initiate an investigation into equipment and procedures by any laboratory is that if the test result is greater than plus or minus two standard deviations from the average of results. For critical tests the standard should probably be changed to plus or minus one or one and a half standard deviations.

4) The difference in philosophy for recycled hot mix by different Sections within the Ministry should be resolved and one policy set and followed.

5) The data generated by testing of hot mix should be better managed. This can be done through the use of control charts and continuous updating of the mean and standard deviation of all test results from all laboratories.

6) When the mobile laboratory is on a contract, no samples should be sent to the regional laboratory. This prevents duplication and eases the work load.

7) When any experiment material is used in hot mix the supplier should be required to submit specifications and the material should be tested during construction to ensure compliance.

RECYCLED ASPHALT PAVEMENT

TEST RESULTS

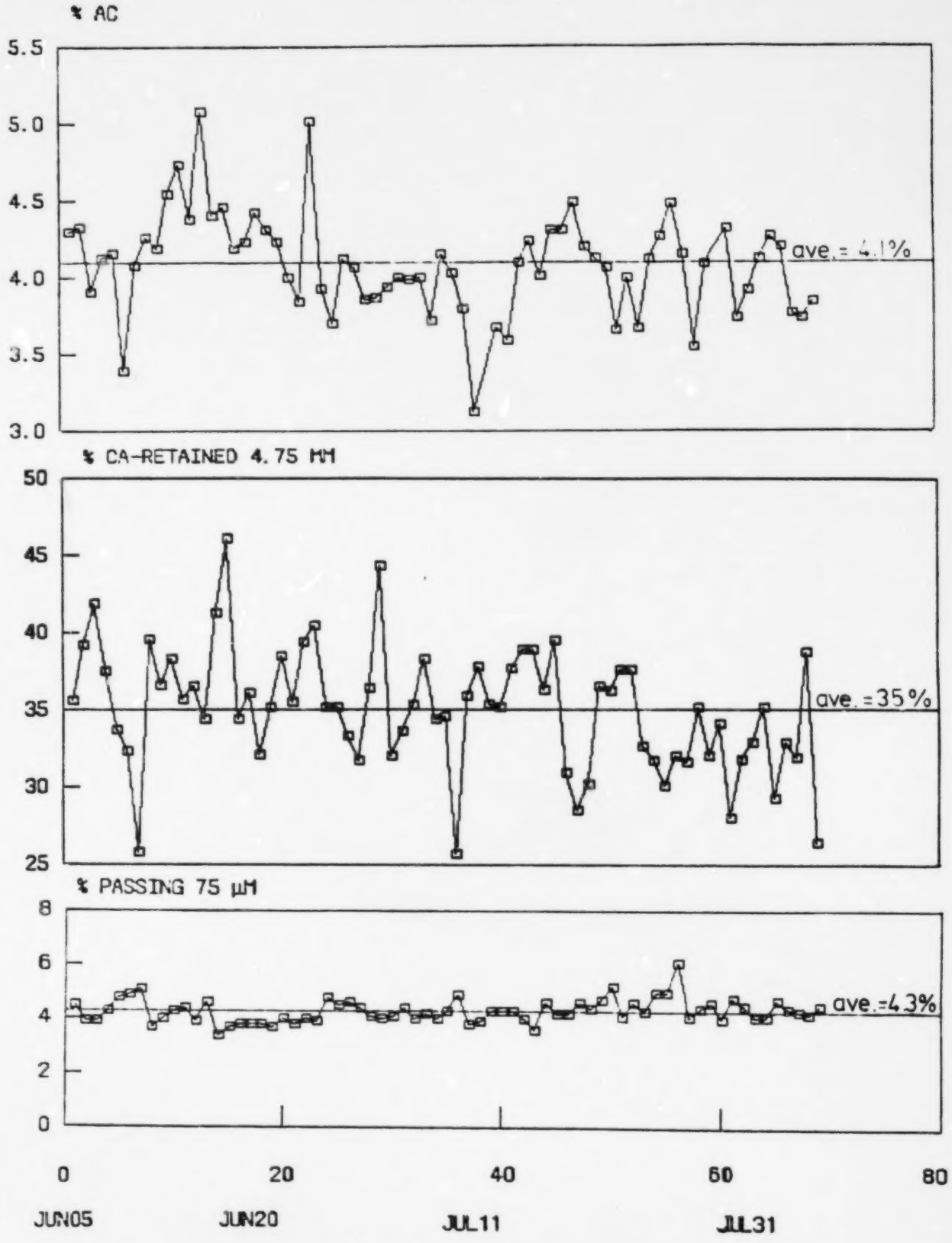


FIG 1

FORM [illegible]
REVISED JUNE 1966

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

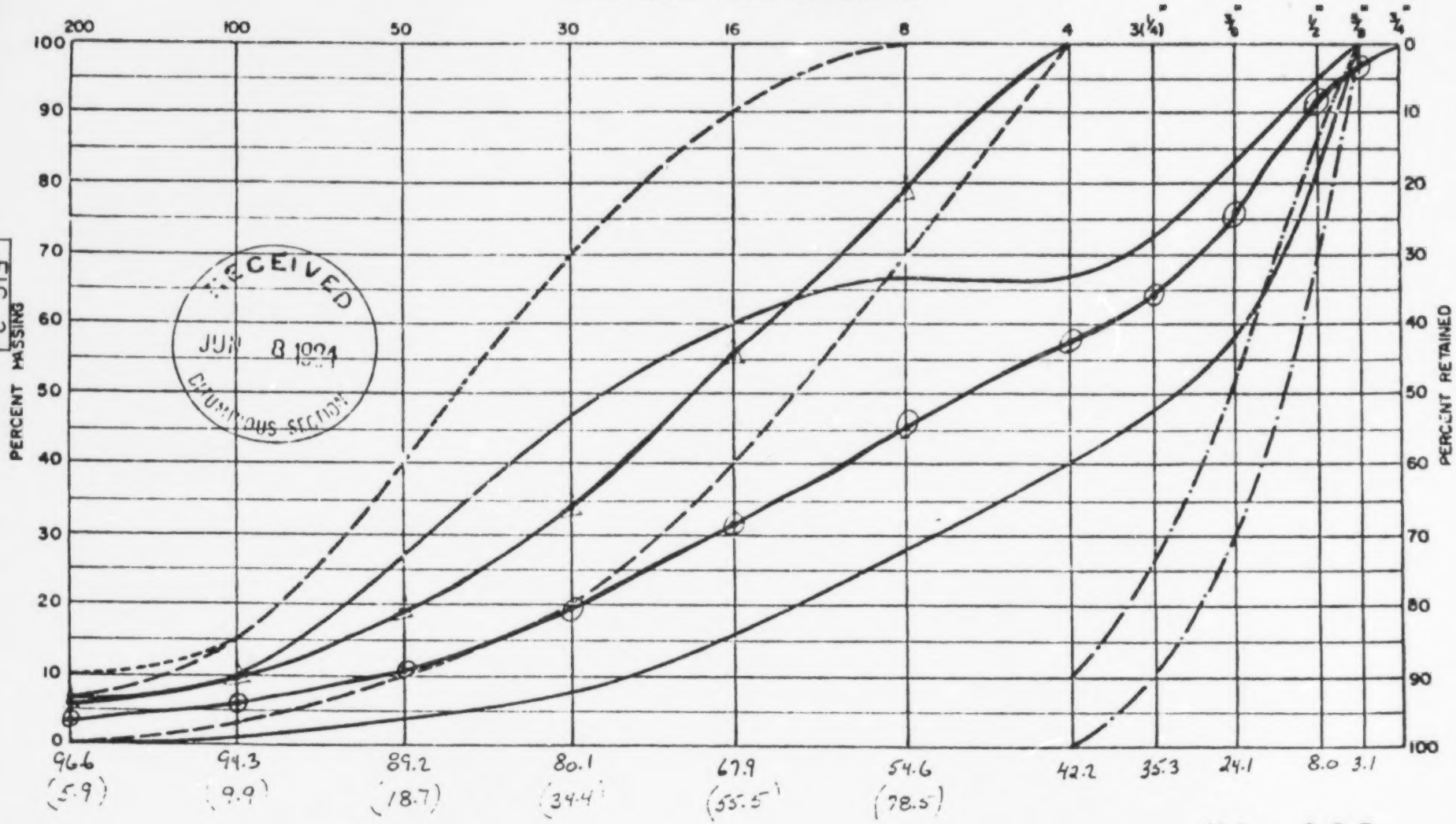
CONT. 83-222

SEMI—LOG GRADING CHART

REC. HL-4 SURFACE.

DEPARTMENT SIEVE DESIGNATION

FIG 2



RECEIVED
JUN 8 1994
CONTRACTS SECTION

H.L.—4 & 5

FORM MP-M1-55
REVISED JUNE 1966

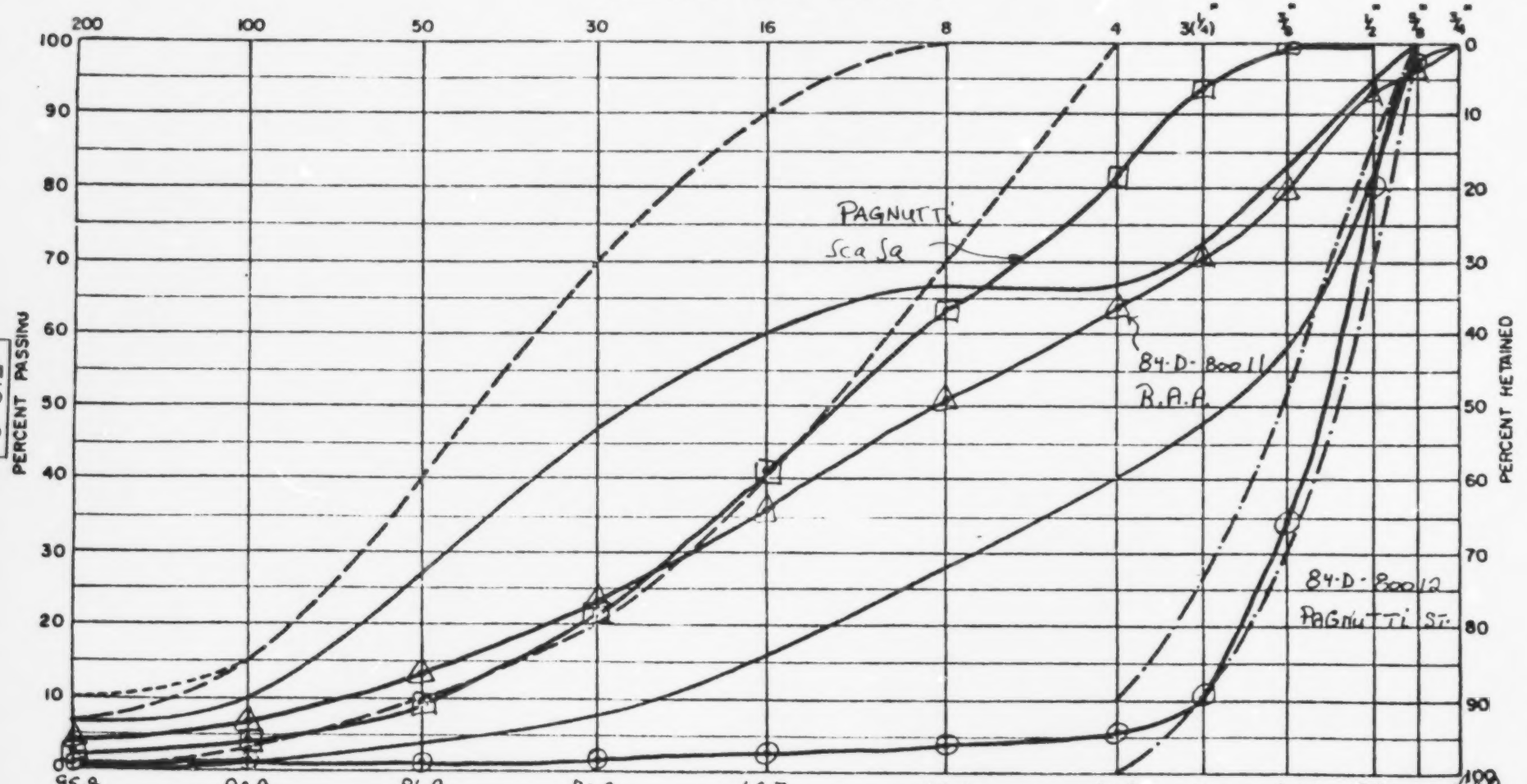
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

CONT 83-222

SEMI—LOG GRADING CHART

H/L 4 - RECYCLED SURFACE.

DEPARTMENT SIEVE DESIGNATION



95.8	92.9	86.9	76.9	63.7	49.3	36.3	29.7	20.1	7.2	3.7	KAP
99.5	99.1	98.5	98.0	97.4	96.5	94.2	90.0	65.9	19.9	3.0	Cal
97.6	95.7	90.6	77.5	57.9	37.1	18.2	6.7	0.9			F+
(97.1)	(94.7)	(88.5)	(72.5)	(48.5)	(23.2)	SB					

H.L.— 4 & 5

FIG 3

- 10 -

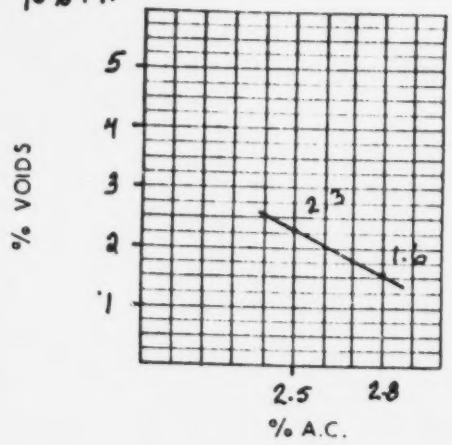
BITUMINOUS MIX DESIGN RESULTS (A)

CONTRACT NO. 83-222 HWY NO. 69

LOCATION FRENCH RIVER NORTHERLY

70% RAP
15% CA
15% FA

% SAND = 57.8 % PASS #4



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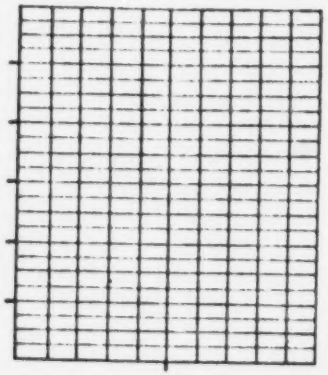

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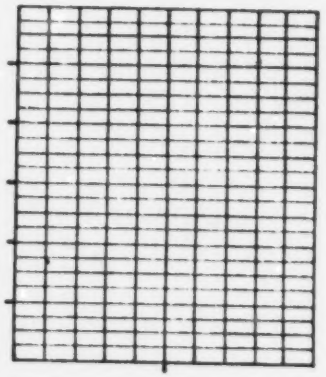
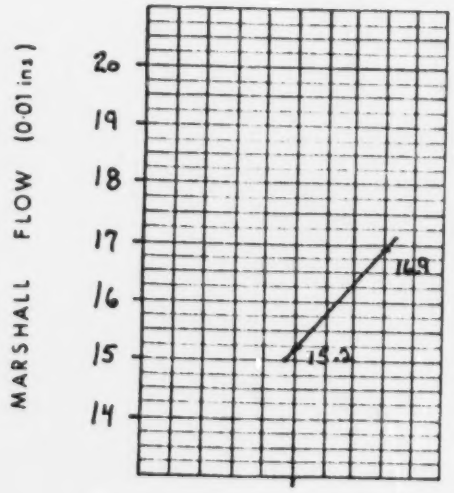
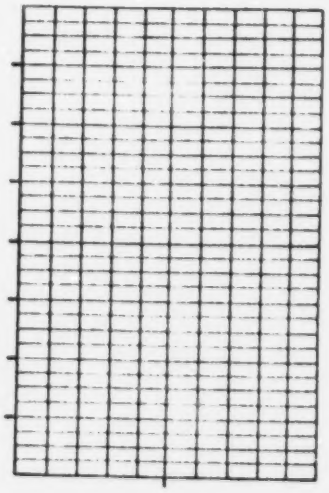






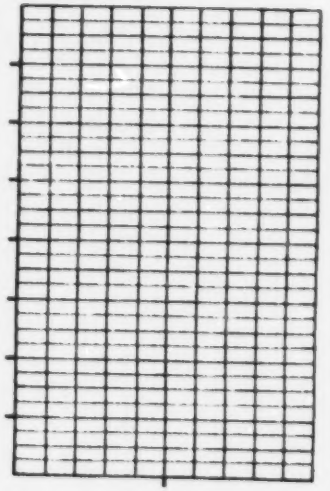


FIG. 4

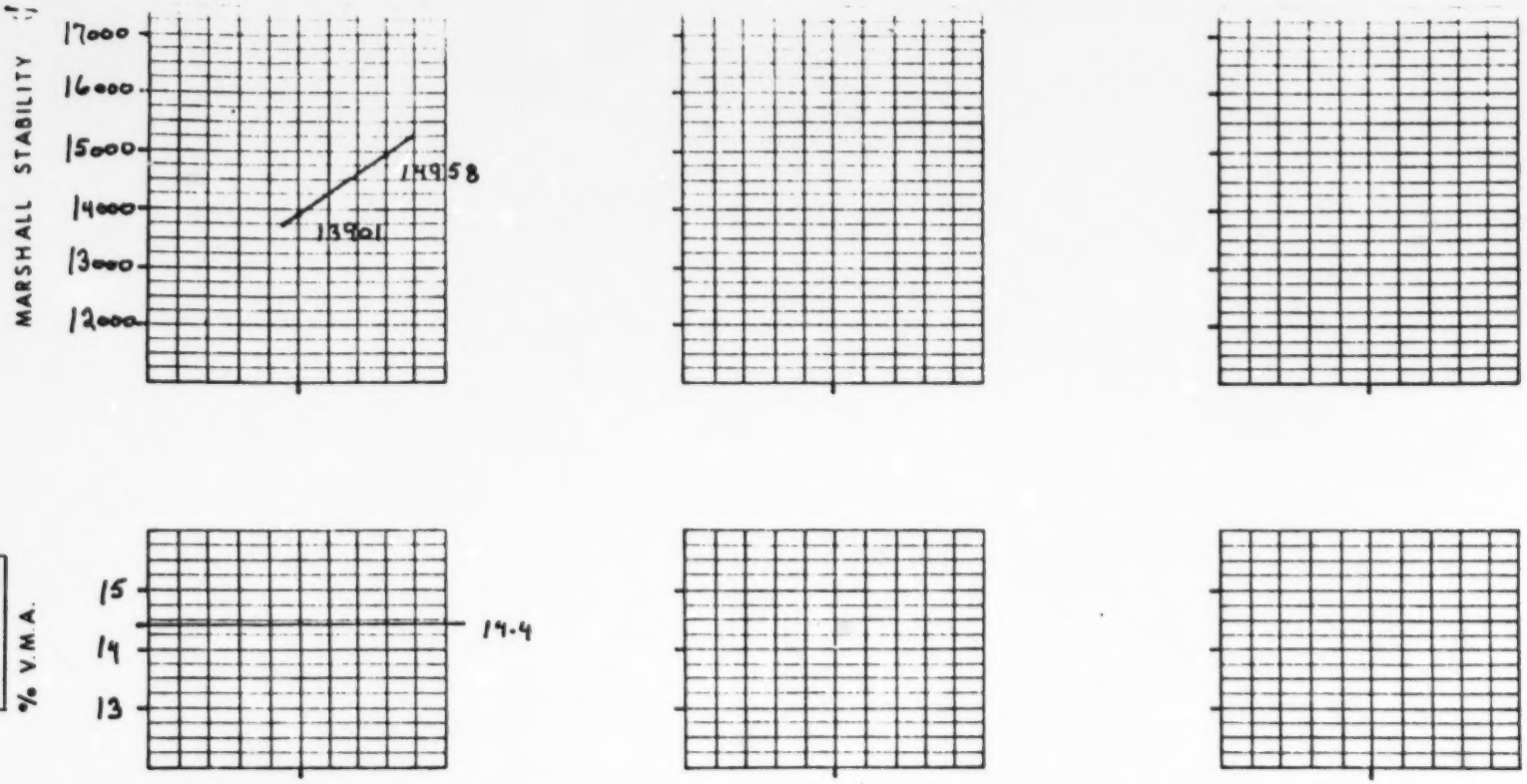


FIG. 5

LAB. MIXES CHOSEN

	NO.1	NO.2	NO.3
% SAND			
% PASS #4	57.8		
% A.C.	+2.6		
% VOIDS	2.0		
FLOW	15.8		
STABILITY	14600		
% V.M.A.	14.4		

INCLUDES A.C ABSORPTION
EXCLUDES A.C. ABSORPTION

FIELD MIXES CHOSEN

	NO.1	NO.2	NO.3
% RET #4	42.2		
% PASS #4	57.8		
% A.C.	5.62		

MATERIAL SOURCES

FINE AGG.#1 R.A.P. 70 %
FINE AGG.#2 PAGGNutt Sca. Sa 15 %
COARSE AGG. PAGGNutt Stone 15 %
ASPHALT Gulf AA 75

REMARKS 70% RAP + 15% CoAgg +
Mix is For HL-4 PADDING & SURFACE

70% RAP ADDS 3.02% A/C to Total Mix.

84-D-80011 - RAP. BSG 2.700 AAS 0.618
80012 - STONE " 2.741 " 0.283
80013 - SAND " 2.711 " 0.442

Co Agg Comb. " 2.731
Fi Agg Comb " 2.693

DATE JUNE 6 1984

RECYCLED HOT MIX - Item No 19

FIG 6

CONTRACT NO 83-222

Scope

This special provision covers the requirement for producing and placing recycled hot mix.

Materials

Reclaimed asphalt pavement materials used in recycled hot mix shall not exceed 1.5in. in the least dimension when introduced into the asphalt plant and shall be obtained from the reclaimed asphalt pavement produced on this project.

The virgin aggregate shall be separated coarse and fine aggregates; the ratio of coarse to fine aggregate shall be 70/30. The coarse aggregate shall meet the gradation and quality requirements of HL 4 as specified in Form 1003. The fine aggregate shall grade fine and clean and shall meet the physical and quality requirements of HL 4 as specified in Form 1003.

Asphalt cement shall be 300/400 meeting the requirements of Form 1101.

Composition of the Mixture

The recycled hot mix shall consist of:

Reclaimed asphalt pavement material	- 70% by mass
Virgin Aggregate	- 30% by mass
New Asphalt Cement	- 2% by mass $\pm$ 0.5%

The actual composition of the mixture will be determined by mix design.

Construction

The recycled hot mix shall be produced and placed according to the requirements of Form 310, except as otherwise specified in this special provision.

Prior to placing hot mix, milled surfaces shall be free of consolidated asphalt rich dust.

An asphalt plant meeting the requirements of Form 310 and modified to process reclaimed asphalt pavement material shall be used to produce the recycled hot mix. When drying aggregate the limit of 165 degrees C for aggregate temperature shall not apply.

Double Drying

Double drying of reclaimed asphalt pavement materials shall not be a requirement.

Measurement for Payment

Measurement for payment for recycled hot mix shall be in tons according to the requirements of Form 502.

Basis of Payment

Payment at the contract price for the above tender item shall be full compensation for all labour, equipment and material required to do the above work.

Cancellation of the Surface Course Trial Area

No surface course trial area shall be required on this contract.

Hot Mix Spreading Equipment

For the purpose of laying levelling, binder and surface courses as required under this contract, two pavers shall be used wherever, in the opinion of the

Engineer, it is practical to do so. The pavers shall be operated at the same time within 200 feet of each other so that a hot joint is obtained between the lanes of mixture being placed. Should one paver break down while placing levelling, binder or surface course, the Engineer may permit the day's work to be completed with the one paver only. The Contractor shall supply sufficient personnel to adequately control both spreading operations.

Automatic Screed Controls

MTC Form 310 is amended in that automatic screed controls are not required.

Frozen Roadbed

The first paragraph of Subsection 310.07.06, Placing Asphalt Mixture, is deleted and replaced by:

Paving shall not be carried out if, in the opinion of the Engineer, the roadbed is frozen. In case of disagreement, the Contractor has the option of demonstrating, at his own expense and to the satisfaction of the Engineer, that the roadbed is frost-free.

Tarpaulins

Sub-section 310.05.01, Asphaltic Concrete Material, of Form 310 is amended in that the requirements of Sub-section 1150.08.01, Transportation of the Mixture, that trucks be equipped with tarpaulins and the mix covered with a tarpaulin, are deleted.

Anti-Stripping Additives

This Special Provision covers the requirements for the use of anti-stripping additives in Hot Mix Asphaltic Concrete.

Materials

The anti-stripping additive used shall be one of the products listed in the Designated Sources List.

General Requirements

All sources on the aggregate sources list requiring an anti-stripping additive are so identified. When the Contractor obtains aggregates from a source not listed on the aggregate sources list, the requirements for an anti-stripping additive and the amount shall be based on Ministry laboratory tests.

In all cases where an anti-stripping additive is required the amount will range between 0.5% and 1.0% of the asphalt cement content.

Mixing Requirements

Except as otherwise noted on the Designated Sources List, anti-stripping additives will require heating to between 140 Degrees F to 180 Degrees F for proper flow characteristics when pumping. The anti-stripping additive shall be uniformly mixed into the asphalt cement prior to incorporating the asphalt cement into the mix.

Basis of Payment

Payment at the contract price(s) for the above hot mix tender item(s) shall include compensation in full for all labour, equipment and material required to incorporate anti-stripping additive into the hot mix asphaltic concrete.

For purposes of stock reconciliation when determining the quantity of asphalt cement used, a deduction will be made for the amount of anti-stripping additive used in the mix.

ACCEPTANCE TEST RESULTS—FIELD LABORATORY

RHM

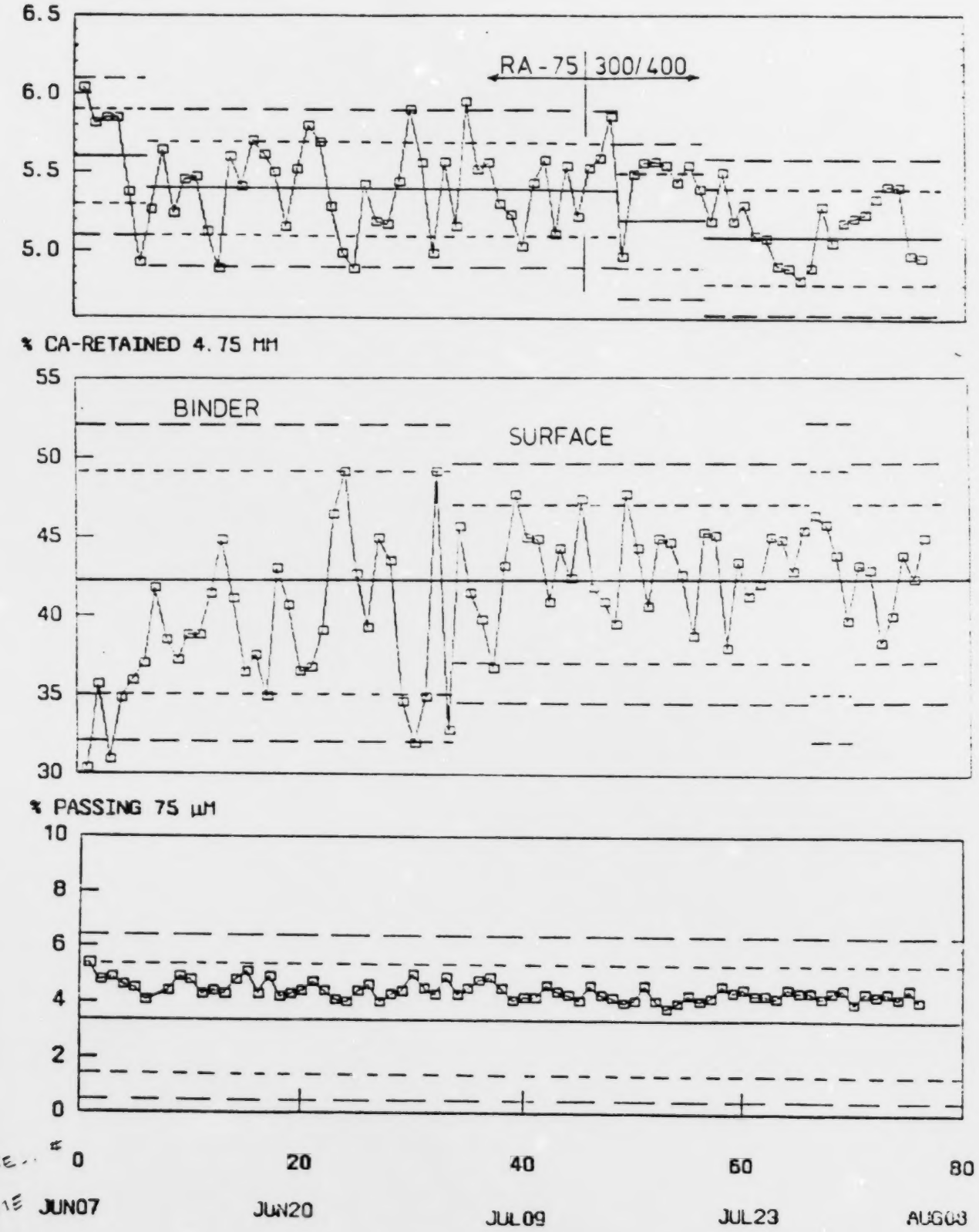
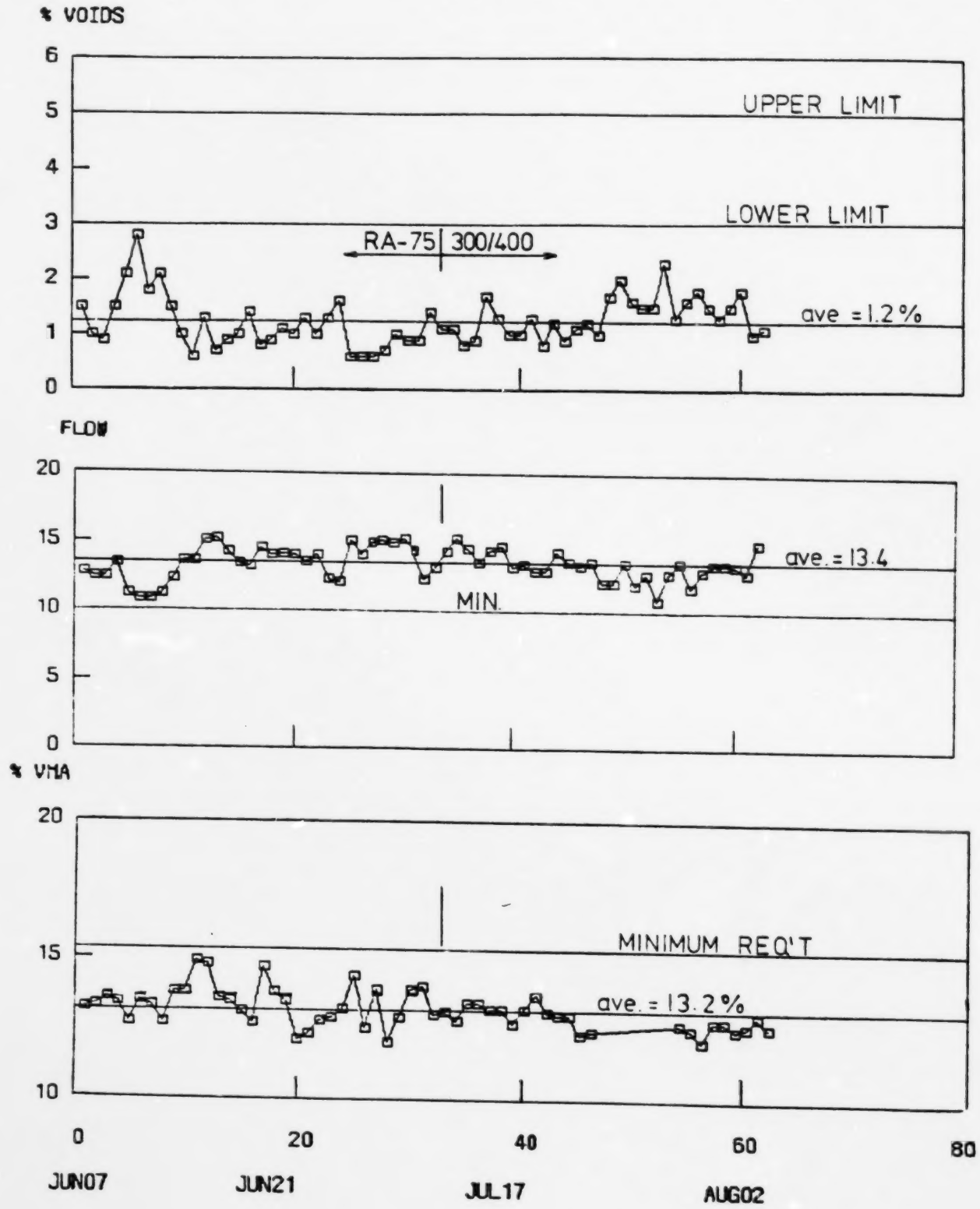


FIG 7

REGIONAL MOBILE LABORATORY

TEST RESULTS



TEST NUMBER AND DATE

FIG 8

REGIONAL STATIONARY LABORATORY

TEST RESULTS

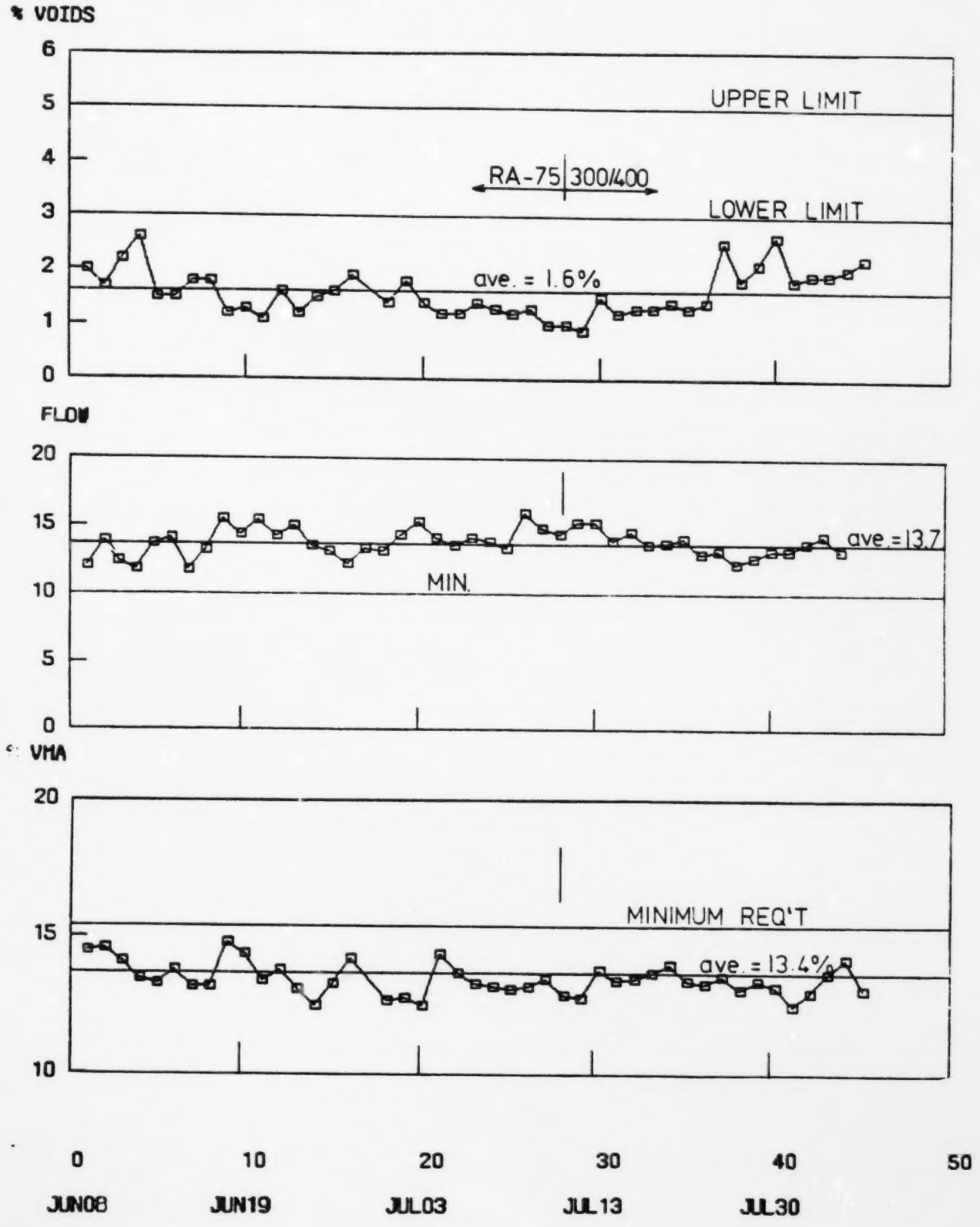


FIG. 9

83-222

Mr. D.F. Barnes,
Manager, Construction Office,
North Bay Region.

Bituminous Section,
Downsview.

24 02 02

Contracts 83-212 and 83-222 - "Soft" Asphalt

As per our discussion, Mr. T.G. Smith has approved changing the grade of asphalt cement for the above contracts from 300/400 to either Petrocan 500, Gulf PA-75 or Chevron 5.2, based on low bid.

Can you arrange to requisition these three alternates for the contracts in question?

G. Petro has informed me (in the interim) that Cont. 83-212 may not be a candidate if the Contractor elects not to recycle. Can this be resolved?

D. F. Lynch,
Head, Bituminous Section.

DFL:mv

cc: C. LaSelle
D.J. Armatage

FIG 10

203

83-222

84 07 30

TO: File

Re: Contract 83-222 - RA-75

This contract was visited by Guy Cautillo and myself on Wednesday July 11, 1984, at the request of S. Wilson, Area Construction Engineer. The mix design was 70:30 recycled for HL-4 with 5.62% A.C., 2% voids and 14.4% V.M.A. The plus 4.75 mm was 42.2%. The mix was designed with the RA-75 asphalt cement and gave flows of 15.8 and a stability of 14600. The virgin aggregate portion was originally designed at 15% coarse and 15% fine and later changed to 20% coarse and 10% fines. The A.C. content was changed from 5.6 to 5.4 to 5.2 and finally to 5.1%.

The contract consisted of some patching followed by resurfacing with recycled hot mix. At the time of inspection, most of the patches were done as well as some 6 km of resurfacing.

All the paving showed some degree of flushing. This appeared as an oily asphalt cement skim in the wheel tracks. Its degree varied and on some portion the tires made the typical sound associated with flushing. This flushing, in some cases, was worn off by a week's traffic and in other cases, was not.

Noticeable rutting in the wheel paths was as well occurring. During the paving operation there was nothing unusual in the appearance of the mix. After rolling with a vibratory and rubber-tire roller, a boot heel could easily be pushed through the lift just placed. There was substantial movement of the mix in front of the tires of trucks with some subsequent rutting.

The variation of the R.A.P. based on standard deviations was not unusual. The contractor, Smith, after numerous letters and infraction reports informed MTC staff that he would no longer adjust his plant other than on instructions from MTC.

After discussing the situation with the construction as well as the regional staff, it was agreed to eliminate the RA-75 and return to 300/400 asphalt cement.

Subsequent phone calls indicated that this had helped, however, some flushing was still occurring. The asphalt cement content was subsequently lowered from 5.2 to 5.1.

P. Korgemagi

P. Korgemagi
Sr. Bituminous Engineer.

PK:mv

FIG. 11

HWY 69 - CONTRACT 83-222, RA-75 RECYCLE MIX

PARAMETER / CORE	B.R.D.	% COMP.	% V.I.P.	MARSHALL RESULTS ON COMBINED A, B, C								
				B.R.D.	M.R.D.	VOIDS	STAB KN	FLOW	% VMA	+ 4.75	- 75	A.C.
1A	2.460	98.9	2.2	2.488	2.516	1.1	11.249	14.8	13.5	44.3	4.0	5.83
1B	2.485	99.9	1.2									
1C	2.485	100.0	1.2									
3A	2.465	99.1	2.1	2.487	2.517	1.2	11.026	14.9	13.2	45.6	4.0	5.41
3B	2.479	99.7	1.5									
3C	2.470	99.3	1.9									
5A	2.477	99.9	1.2	2.490	2.508	1.1	10.925	15.4	14.0	45.2	4.1	6.04
5B	2.477	99.9	1.2									
5C	2.495	100.6	0.5									
6A	2.484	99.5	1.6	2.496	2.525	1.1	12.467	14.3	13.0	47.4	4.0	5.46
6B	2.479	99.3	1.8									
6C	2.476	99.2	1.9									

A = Righthand wheel track

B = Between wheel track

C = Lefthand wheel track

1 - Station 427+36

3 - Station 452+30

5 - Station 100+60

6 - Station 449+28

FIG. 12

HWY 69 - CONTRACT 83-222, 300/400 RECYCLE MIX

PARAMETER / CORE	B.R.D.	% COMP	% V.I.P.	MARSHALL RESULTS ON COMBINED A, B, C								
				B.R.D.	M.R.D.	VOIDS	STAB KN	FLOW	% VMA	+ 4.75	- 75	% A.C.
13A	2.421	96.9	4.3	2.499	2.529	1.2	14.168	15.6	13.0	36.9	4.0	5.78
13B	2.452	98.1	3.0									
13C	2.442	97.7	3.4									
14A	2.445	97.7	3.6	2.502	2.537	1.4	13.589	12.7	12.7	45.8	4.3	5.40
14B	2.458	98.2	3.1									
14C	2.456	98.2	3.2									
15A	2.437	97.9	3.4	2.494	2.523	1.1	12.629	14.0	13.1	47.3	4.0	5.52
15B	2.427	97.3	3.8									
15C	2.414	96.8	4.3									
16A	2.423	97.0	4.3	2.498	2.531	1.3	13.878	13.6	12.6	42.9	4.4	5.26
16B	2.433	97.4	3.9									
16C	2.423	97.0	4.3									

A = Righthand wheel track
B = Between wheel track
C = Lefthand wheel track

13 - Station 456+07
15 - Station 375+75
14 - Station 420+50
16 - Station 339+58

FIG 13

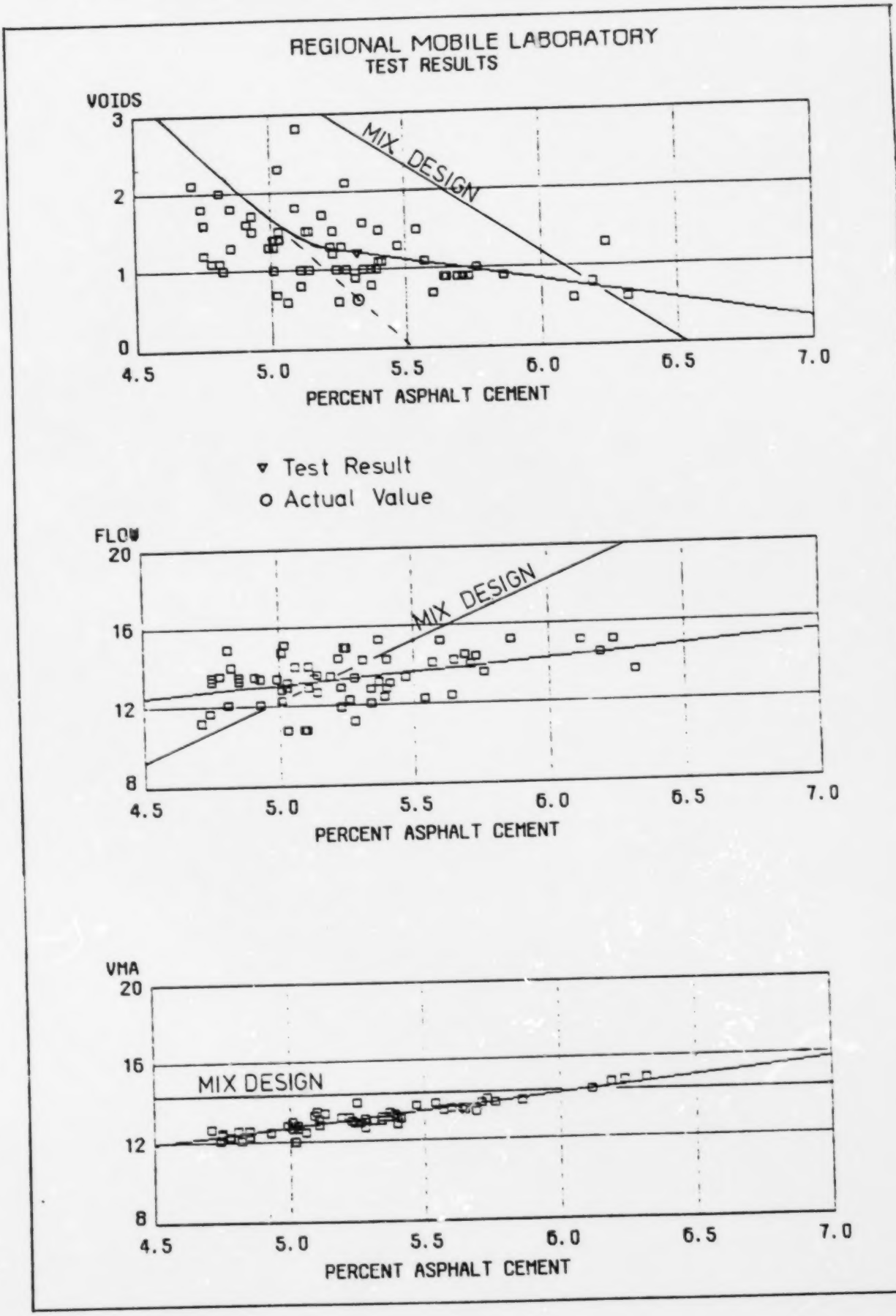

REGIONAL MOBILE LABORATORY
TEST RESULTS
VOIDS
3
2
1
0
MIX DESIGN
4.5
5.0
5.5
6.0
6.5
7.0
PERCENT ASPHALT CEMENT
▿ Test Result
o Actual Value
FLOW
20
16
12
8
MIX DESIGN
4.5
5.0
5.5
6.0
6.5
7.0
PERCENT ASPHALT CEMENT
VMA
20
16
12
8
MIX DESIGN
4.5
5.0
5.5
6.0
6.5
7.0
PERCENT ASPHALT CEMENT

FIG. 14

TABLE 1

RAP – A.C. & GRADATION (% retained)						
Parameter	AC	13.2 mm	4.75 mm	600 µm	300 µm	% passing 75 µm
$\bar{x}$	4.1	6.9	35.0	75.5	86.1	4.3
s	0.33	3.24	4.00	1.99	1.43	0.45
n	69	55	69	55	55	69
CV	8.0					

TABLE 2

HOT MIX AGGREGATES								
COARSE AGGREGATE GRADATION (% retained)								
Parameter	19.0 mm	16.0 mm	13.2 mm	9.5 mm	4.75 mm	% crush	%loss 75 µm	
$\bar{x}$	0.2	4.0	24.1	67.8	94.2	76.8	0.2	
s	0.07	1.04	4.48	5.64	2.52	4.61	0.07	
n	7	33	33	33	32	12	2	
FINE AGGREGATE GRADATION (% retained)								
Parameter	9.5 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	300 µm	150 µm	%pass 75 µm
$\bar{x}$	0.4	13.5	34.5	55.6	74.8	88.4	94.3	3.6
s	0.32	3.94	6.43	6.14	5.57	2.95	1.53	0.97
n	16	27	26	26	27	27	27	27

TABLE 3

FIELD LABORATORY ACCEPTANCE TEST RESULTS						
RHM – A.C. & GRADATION (% retained)						
Mix	Parameter	AC	4.75 mm	600 µm	300µm	% pass 75 µm
RHM RA–75	$\bar{x}$	5.4	40.0	78.2	87.4	4.5
	s	0.30	4.84	1.34	0.77	0.32
	n	45	45	44	44	44
	CV	5.6				
RHM 300/400	$\bar{x}$	5.3	42.8	79.4	88.0	4.3
	s	0.26	2.53	0.78	0.54	0.20
	n	31	31	31	31	31
	CV	4.9				
RHM TOTAL	$\bar{x}$	5.4	41.1	78.7	87.7	4.4
	s	0.29	4.27	1.27	0.75	0.29
	n	76	76	75	75	75
	CV	5.4				

n = number of tests

$$\bar{x} = \frac{\sum x}{n}$$

$$s = \sqrt{\frac{\sum (\bar{x}-x)^2}{n-1}}$$

$$CV = \frac{s}{\bar{x}} (100)$$

TABLE 4

MOBILE LABORATORY RESULTS									
RHM – A.C. & GRADATION									
Mix	Para-meter	AC	%ret 4.75 mm	%pass 75 µm	%Voids	Flow	Stability	%VMA	%Comp
RHM RA-75	$\bar{x}$	5.4	40.5	4.2	1.2	13.5	12183.1	13.3	96.8
	s	0.41	5.23	0.27	0.49	1.31	1345.0	0.72	0.91
	n	34	34	34	34	34	34	34	10
	CV	7.6			40.8	9.7	11.0	5.4	
RHM 300/400	$\bar{x}$	5.1	44.7	3.7	1.4	13.3	12992.2	12.9	96.6
	s	0.24	3.46	0.23	0.38	1.01	791.3	0.41	–
	n	28	28	28	28	28	28	21	1
	CV	4.7			27.1	7.6	6.1	3.2	
RHM TOTAL	$\bar{x}$	5.3	42.4	4.1	1.2	13.4	12548.5	13.2	96.8
	s	0.38	4.96	0.29	0.45	1.18	1191.9	0.66	0.87
	n	62	62	62	62	62	62	55	11
	CV	7.2			37.5	8.8	9.5	5.0	

TABLE 5

REGIONAL LABORATORY RESULTS								
RHM – A.C. & GRADATION								
Mix	Parameter	AC	%ret 4.75 mm	%pass 75 µm	%Voids	Flow	Stablity	%VMA
RHM TOTAL	$\bar{x}$	5.5	41.7	4.6	1.6	13.7	12603.2	13.4
	s	0.35	4.65	0.49	0.43	1.03	1357.4	0.57
	n	45	45	44	44	44	44	44
	CV	6.4			26.8	7.5	10.8	4.3

TABLE 6

ASPHALT CEMENT					
SAMPLES – TESTED IN NORTHERN REGION					
300/400			RA–75		
Parameter	Pen.	Kin. Visc. @135°C (mm^2/s)	Pen.	Kin. Visc. @135°C (mm^2/s)	Kin. Visc. @ 60°c (mm^2/s)
$\bar{x}$	325.0	167.6	525.8	99.5	10870
s	20.6	16.0	53.2	1.1	517.1
n	21	21	24	6	7
CORE – SAMPLES			ABSON RECOVERY		
TESTED IN NORTHERN REGION					
TEST	69.0	383.6	81.0	305.0	–
TESTED IN DOWNSVIEW					
TEST	–	–	125	241	–
TEST	–	–	176	203	–

TABLE 7 (1)

CORE RESULTS RELATED TO DIRECTIVE B-138

Job-Mix-Formula		AC 5.4%		CA 42.2%		75 µm 3.4%	
DATE	LIFT	AC RA-75	ZONE	CA	ZONE	75µm	ZONE
84 06 19	PADDING	5.46	A	40.2	A	4.3	A
84 06 19	PADDING	5.12	A	38.3	A	4.2	A
84 06 19	PADDING	5.59	A	35.6	A	4.4	A
84 06 19	PADDING	4.74	R	46.2	A	3.7	A
84 06 19	PADDING	4.87	R	42.7	A	4.2	A
84 06 19	PADDING	4.79	R	47.1	A	3.9	A
84 06 19	PADDING	5.49	A	41.5	A	4.1	A
84 06 19	PADDING	5.00	BL	40.4	A	4.5	A
84 06 19	PADDING	4.84	R	41.9	A	4.5	A
84 06 19	PADDING	5 63	A	35.6	A	4.6	A
84 06 19	PADDING	5 48	A	44.1	A	4.1	A
84 06 19	PADDING	5 40	A	41.0	A	4.6	A
84 06 19	PADDING	5.28	A	43.9	A	4.1	A
84 06 25	BINDER	5.34	A	47.7	A	3.9	A
84 06 25	BINDER	4.76	R	42.8	A	4.4	A
84 06 25	BINDER	5.20	A	44.7	A	4.4	A
84 06 25	BINDER	5.83	BL	40.5	A	4.3	A
84 06 25	BINDER	5.35	A	41.0	A	4.2	A
84 06 25	BINDER	5.26	A	39.7	A	4.5	A
84 06 25	BINDER	5.31	A	37.0	A	4.0	A
84 06 25	BINDER	5.50	A	38.0	A	4.5	A

TABLE 7(2)

CORE RESULTS RELATED TO DIRECTIVE B-138

Job-Mix-Formula		AC 5.4%		CA 42.2%		75 µm 3.4%	
DATE	LIFT	AC RA-75	ZONE	CA	ZONE	75um	ZONE
84 06 26	PADDING	5.80	BL	38.4	A	4.2	A
84 06 26	PADDING	5.80	BL	38.6	A	4.2	A
84 06 26	PADDING	4.96	BL	47.7	A	3.7	A
84 06 26	PADDING	5.79	BL	34.9	BL	4.1	A
84 06 26	PADDING	5.94	R	35.1	BL	4.2	A
84 07 03	BINDER	4.96	BL	43.0	BL	4.2	A
84 07 03	BINDER	5.20	A	40.9	BL	4.3	A
84 07 03	BINDER	4.96	BL	41.4	BL	3.9	A
84 07 03	BINDER	4.67	R	46.5	BL	4.1	A
84 07 03	BINDER	5.58	A	38.1	BL	4.6	A

TABLE 7 (3)

CORE RESULTS RELATED TO DIRECTIVE B-138

Job-Mix-Formula		AC 5.4%		CA 42.2%		75 µm 3.4%	
DATE	LIFT	AC RA-75	ZONE	CA	ZONE	75µm	ZONE
84 07 05	SURFACE	5.03	BL	46.9	A	3.7	A
84 07 05	SURFACE	5.64	A	41.8	A	4.3	A
84 07 05	SURFACE	5.31	A	44.2	A	4.2	A
84 07 05	SURFACE	5.67	A	42.7	A	3.8	A
84 07 05	SURFACE	6.35	R	35.3	BL	4.4	A
84 07 05	SURFACE	6.41	R	35.8	BL	4.5	A
84 07 05	SURFACE	5.89	BL	36.7	BL	4.5	A
84 07 05	SURFACE	5.41	A	47.1	A	4.1	A
84 07 05	SURFACE	5.62	A	43.8	A	4.2	A
84 07 05	SURFACE	5.08	BL	52.8	R	3.8	A
84 07 05	SURFACE	4.82	R	54.8	R	3.9	A
84 07 05	SURFACE	4.35	R	57.1	R	3.8	A
84 07 09	SURFACE	4.63	R	61.0	R	3.5	A
84 07 09	SURFACE	5.85	BL	43.5	A	4.2	A
84 07 20	BINDER	6.21	R	38.0	A	4.5	A
84 07 20	BINDER	5.95	R	40.3	A	4.4	A
84 07 20	BINDER	6.75	R	35.4	A	5.2	A

TABLE 7 (4)

CORE RESULTS RELATED TO DIRECTIVE B-138

Job-Mix-Formula		AC 5.2%		CA 42.2%		75 µm 3.4%	
DATE	LIFT	AC 300/400	ZONE	CA	ZONE	75µm	ZONE
84 07 24	SURFACE	5.02	A	44.4	A	4.0	A
84 07 24	SURFACE	5.72	R	41.8	A	4.2	A
84 07 24	SURFACE	5.60	BL	42.9	A	4.1	A

Job-Mix-Formula		AC 5.1%		CA 42.2%		75 µm 3.4%	
DATE	LIFT	AC 300/400	ZONE	CA	ZONE	75µm	ZONE
84 08 07	SURFACE	5.93	R	40.0	A	4.2	A
84 08 07	SURFACE	5.47	A	42.3	A	4.3	A
84 08 07	SURFACE	5.48	A	42.0	A	4.0	A
84 08 07	SURFACE	5.04	A	46.5	A	3.9	A
84 08 07	SURFACE	5.73	R	39.7	A	4.2	A
84 08 07	SURFACE	5.45	A	41.4	A	4.4	A
84 08 07	SURFACE	5.48	A	41.4	A	4.3	A